

# Robotic Handling and Processing of Mixed Wastes

*Faster, safer, better, cheaper*

**A**t LLNL, we are developing automated systems for handling and processing DOE weapons complex wastes.

Currently, such activities must be performed in containment systems (ranging in size from glove boxes to entire rooms). Or, the work must be performed by human operators in fully encapsulated suits, which generally exposes the operator to ionizing radiation, even with the shielding and protective clothing. It also exposes the operator to the risk of accident due to such hazards, as mechanical failure or an accidental tear in the protective suit.

## Automated handling, separation, and analysis of mixed wastes

We have demonstrated automation and robotics hardware and software capable of carrying out three difficult tasks associated with mixed-waste operations.

**Singulation.** This is the removal of a single item of waste from a container or pile of objects. We have developed the technology to do this both as an autonomous robotic task (no operator intervention) and, for more complex situations, as a vision-based (teleoperated) task in

which a human operator controls the robot's operations ("human in the loop"). This required the design and construction of devices that can safely and securely grip objects of widely varying shape, size, and weight. It also required the development of software capa-

ble of determining the shape of an object and how best to grasp that object to manipulate it.

**Characterization and sorting.** We have developed autonomous techniques for characterizing the nature of mixed-waste objects once they have been "singulated." The objects can be homogeneous or inhomogeneous and of greatly differing characteristics. Characterization is needed again in the final stages for inspection to confirm treatment results. Characterization involves nondestructively and noninvasively determining

the weight, structure, radioactivity, and chemical or other toxicity of the object—and localizing the radioactivity and toxicity, if any.

Our characterization tools include radiography, computed tomography, gamma-ray spectroscopy, x-ray fluorescence, and eddy-current metal detection. These tools allow us to separate metals from nonmetals and identify homogeneous solid objects suitable for surface decontamination. We can identify the elements of heterogeneous waste items. And, we can characterize the contents of intact waste drums.

**Waste processing operations.** We have developed an automated system for handling and treating noncombustible mixed waste—including the handling and decontamination of lead bricks. In addition, we have demonstrated a teleoperated system for cleaning objects of more complex shapes. In all these demonstrations, the treatment method used is a commercially available frozen-CO<sub>2</sub> cleaning system.

## Recent work

We have demonstrated the integrated operation of our singulation, characterization, and processing technologies. In this demonstration, unknown objects representing typical mixed waste were segregated, characterized, treated, and inspected in autonomous mode. When needed, the operations can be performed with a "human in the loop" for added flexibility and reliability. Simpler, repetitive tasks can be carried out autonomously.

**Availability:** This technology is available now. The Laboratory seeks industrial partners with whom to further develop the technology and find applications for its use.

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## APPLICATIONS

Handling and processing of:

- Radioactive waste
- Mixed waste
- Hazardous waste